ELSEVIER
Available online at www.sciencedirect.com
ScienceDirect
Procedia Engineering 68 (2013) 338 – 344
Procedia Engineering
www.elsevier.com/locate/procedia

The Malaysian International Tribology Conference 2013, MITC2013

Reducing Wear and Friction by Means of Lubricants Mixtures

Mohd Azman Abdullah[a]*, S.A. Saleman[a], Noreffendy Tamaldin[a],

Muhammad Shahmi Suhaimi[a]

[a]*Faculty of Mechanical Engineering,Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya,76100 Durian Tunggal, Melaka, Malaysia*

Abstract

In this study, two types of lubricants are mixed together in order to maximize wear reduction. Various compositions of mixtures are compared in terms of viscosity index, coefficient of friction and wear scar diameter. Heavy duty engine oil (HDEO) and automatic transmission fluid (ATF) have been used a lubricant condition. The standard procedures used in this study are ASTM D2270 for viscosity test method and ASTM D4172 for four balls tribology test method. Mixture of HDEO and ATF produces better friction resistance as compared to the original HDEO. The benefit of ATF can be used for engine lubrication.

Selection and peer-review under responsibility of The Malaysian Tribology Society (MYTRIBOS), Department of Mechanical Engineering, Universiti Malaya, 50603 Kuala Lumpur, Malaysia

Keywords: Lubricants mixtures; Heavy duty engine oil; Automatic transmission fluid; Viscosity, Friction resistance

1. Introduction

Engine lubrication is the process or technique to reduce wear of one or both surfaces in close proximity and it moving relative to each other by interposing a substance called lubricant between the surfaces to carry the load which mean the pressure generated between the opposing surfaces [1]. In the most common cases the applied load is carried by pressure generated within the fluid due to the frictional viscous resistance to motion of the lubricating fluid between the surfaces [2]. Lubrication can also describes the phenomenon such reduction of wear occurs without human intervention. Adequate lubrication allows smooth continuous operation of equipment with only mild wear and without excessive stresses or seizures at bearings [3]. When lubrication breaks down, metal or other components can rub destructively over each other causing destructive damage, heat and failure [4-6]. The lubricants mixtures benefit from properties of various lubricants. They are useful lubricants that can give best protection to the engine and reducing wear and friction generated from sliding between two contact surface when engine in started condition. Currently, there is no research to analyze the performance of lubricant mixtures. Drivers and mechanics performed trial and errors in order to get the perfect mixture ratio between HDEO and ATF [7-9]. They applied the lubricant mixtures and tried on the vehicle engine and compared the performance by observation during actual vehicle operation. However, the results of experiment are merely subjective to the person's opinion and feeling toward engine vibration, engine ignition condition and after used lubricant condition.

* Corresponding author. Tel.: +6-06-234-6845; fax: +6-06-234-6884
E-mail address: mohdazman@utem.edu.my

Selection and peer-review under responsibility of The Malaysian Tribology Society (MYTRIBOS), Department of Mechanical Engineering, Universiti Malaya, 50603 Kuala Lumpur, Malaysia
doi:10.1016/j.proeng.2013.12.189

Therefore, to prove their claims on the benefit of lubricant mixtures, a study on the lubricant mixtures is performed. The purpose of this study is to improve the lubricant ability in term of viscosity and thickness that can operate under critical conditions such as high temperature, maximum speed and high loads. This study is also carried out to prove the hypothesis of the benefits of mixture of HDEO and ATF to the performance of petrol engine.

2. Methodology

The properties of the lubricants are shown by Table 1.The mixtures of lubricants are homogenized using WiseTis homogenizer HG-15D machine (Fig. 1a). The mixtures are content of percentages of ATF and HDEO as shown by Table 2. The sample is mixed in 60 ml sample bottle and homogenized at 4000 rpm spinal speed. The viscosity of each sample is tested using standard ASTM D2270 [10] practice. Viscosity meter (Fig. 1b) is used to measure the kinematic viscosity at 40 ^{o}C and 100 ^{o}C. The viscosity index is determined using Equation (1). The four-ball tester machine (Fig. 1c) is use following the ASTM D 4172 [11] standard of tribology testing. The testing conditions are shown by Table 3. The three steel balls with 12.7 mm diameter are clamped together and covered with the lubricant mixtures. Different forces starting at 147 N and then 392 N are applied into the cavity formed by the three clamped balls for three point contact. The temperature of the test lubricants mixtures is set at 75˚C and the top ball is rotated at 1200 rpm for duration of 60 min. The scar diameter is compared between all samples using inverted microscope (Fig. 1d).

$$VI = [\ (L - U) / (L - H)\ ] \times 100 \tag{1}$$

Where,

L = Kinematic viscosity at 40°C of a lubricant of 0 viscosity index having the same kinematic viscosity at 100°C.
H = Kinematic viscosity at 40°C of a lubricant of 100 viscosity index having the same kinematic viscosity at 100°C.
U = Kinematic viscosity at 40°C of the lubricant whose viscosity index is to be calculated

Table 1: Properties of HDEO [12-14] and ATF [15-16]

Properties		Unit	HDEO	ATF
SAE grade			15W-40	10W-20
Viscosity, ASTM D 445	cSt @ 40^{o}C	mm^2/s	104	34.08
	cSt @ 100^{o}C	mm^2/s	14.3	7.19
Viscosity index, ASTM D 2270			140	180
Pour point, ASTM D 97		^{o}C	-30	-45
Flash point, ASTM D 92		^{o}C	215	202

(a) (b) (c) (d)

Fig. 1. (a) WiseTis homogenizer HG-15D, (b) Viscosity meter, (c) Four-ball tester, (d) Inverted microscope

3. Results and Discussion

The value of VI was obtained by comparing the kinematic viscosity value of engine oil at 40 ^{o}C and 100 ^{o}C, and the procedure for calculation is described in ASTM D 2770. Fig. 2 shows kinematic viscosity of the samples at 40 ^{o}C and 100 ^{o}C respectively. Fig. 3 shows the graph of viscosity index. From this figure, it shows that, the increment of percentage of ATF in the mixture reduce the viscosity index up until 50 %, but as the percentage of ATF increases from 60 % to 90%, the viscosity index is increase significantly. This is perhaps due to the property of ATF. At low percentage of ATF, the major contribution of viscous property is HDEO. However, ATF has reduced the viscosity within this range. At high percentage of ATF, the major contribution of viscous property is the ATF itself. Since ATF has better viscosity than HDEO, the major role in increasing the viscosity index comes from ATF. Fig. 4 shows the results of coefficient of friction for each sample. Zero % of ATF means 100 % of HDEO. From the graph, it is shown that, better friction resistance is at 20 % and 40 % of ATF mixtures. Other samples however, do not possessed significant improvement in friction resistance. Fig. 5 shows the graph of wear scar diameter for each sample. From this graph, it is shown that, the best result is at 40 % of ATF mixture where the scar is 454.36 μm (Fig. 6), while full ATF lubricant produces 597.24 μm and full HDEO lubricant produces 672.01 μm (Fig. 7). From these results, the scar diameters are independent and not affected by percentage of lubricants in mixtures.

Table 2. Percentage of lubricants mixtures

Sample	HDEO (%)	ATF (%)
A	10	90
B	20	80
C	30	70
D	40	60
E	50	50
F	60	40
G	70	30
H	80	20
I	90	10
J	0	100
K	100	0

Table 3. Testing condition

Condition	I	II
Temperature	75 ± 2 °C	75 ± 2 °C
Speed	1200 ± 60 rpm	1200 ± 60 rpm
Duration	60 ± 1 min	60 ± 1 min
Load	147 ± 2 N	392 ± 2 N

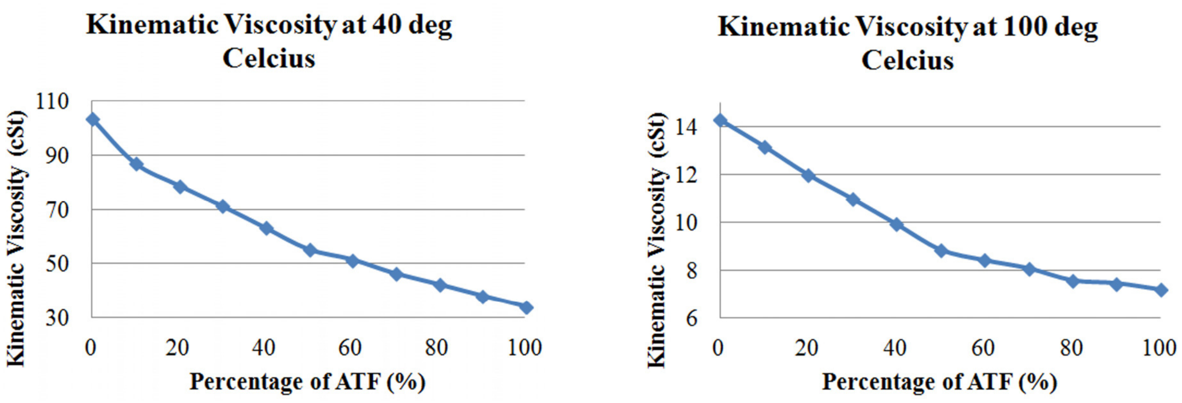

Fig. 2. Result for kinematic viscosity at (a) 40 °C and (b) 100 °C

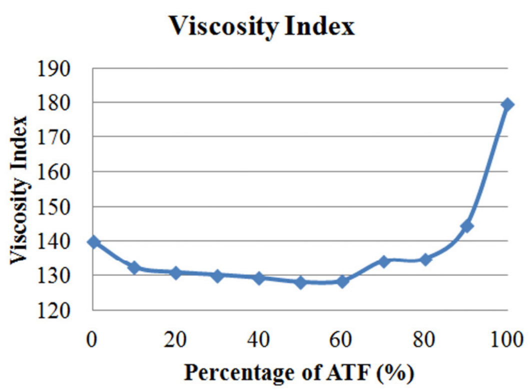

Fig. 3. Result for viscosity index

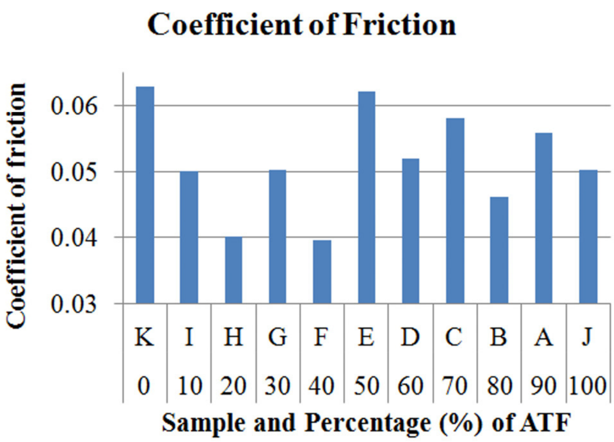

Fig. 4. Result for coefficient of friction

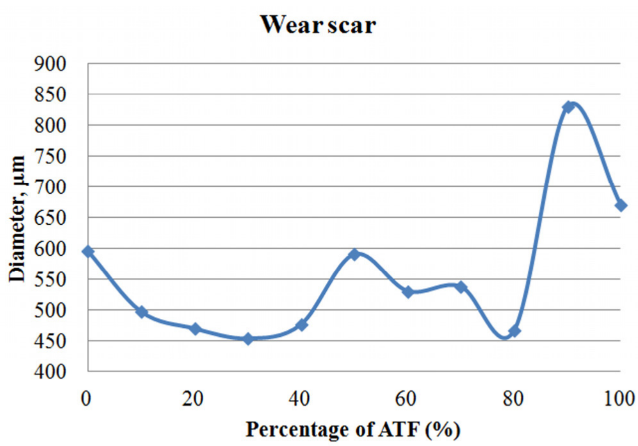

Fig. 5. Result for wear scar diameter

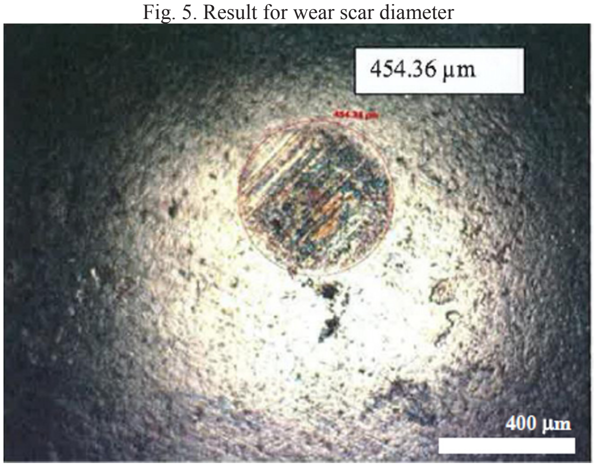

Fig. 6. Wear scar diameter for G (ATF 30 %)

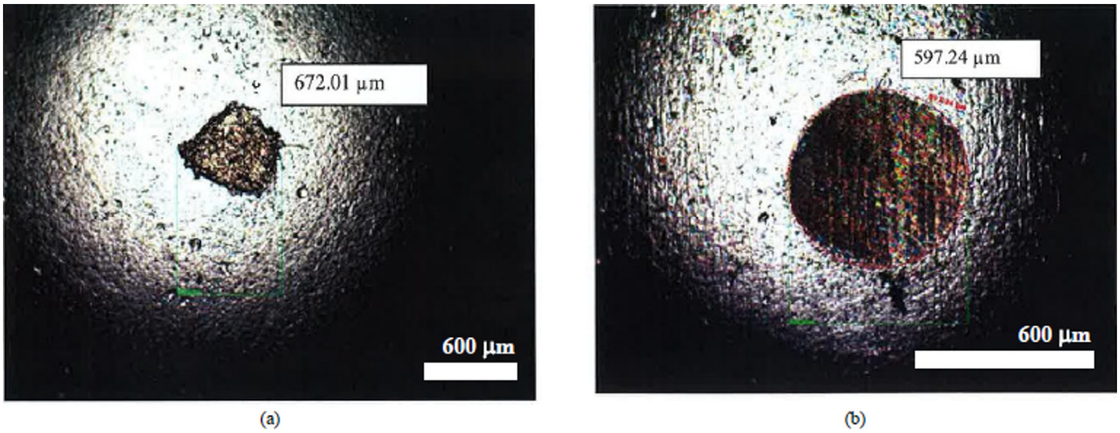

Fig. 7. Wear scar diameter for (a) 100 % ATF, (b) 100 % HDEO

4. Conclusion

The comparisons among lubricants mixtures have been shown in this study. The ATF had minor effect in reducing the viscosity of the mixture until 50 % of its content but significantly increase the viscosity of the mixture for more than 60 % of its content. The lubricant mixture resistance to friction is demonstrated by the result of coefficient of friction. The mixture with 20 % and 40 % of ATF produce the best friction resistance compared to other mixtures. However, in term of wear scar diameter of the three steel balls (fixed balls), various mixtures show different scar diameter as compared to the original HDEO and ATF lubricant. Based on the results, the mixture with 30 % of ATF is superior in terms of wear resistance and suitable for further investigation on actual engine dynamometer testing.

Acknowledgements

The authors gratefully acknowledged the financial support from Universiti Teknikal Malaysia Melaka and The Ministry of Higher Education, Malaysia (MoHE) under Exploratory Research Grant Scheme (ERGS), grant no.: ERGS/1/2012/TK08/UTEM/02/1/E00007.

References

[1] Jones, M.H., Scott, D. E., 1983. Industrial Tribology: the practical aspects of friction, lubrication, and wear. New York, Elsevier Scientific Publishing Company.
[2] ASTM Viscosity Index Calculated From Kinematic Viscosity, 1965. ASTM Data Series DS 39a, American Society for Testing and Materials, 1916 Race Street, Philadelphia.
[3] Mobil Lubricants, 2012. “Mobil Delvac MX”. Website address : http://www.mobil.com/USA-English/Lubes/PDS/NAUSENCVLMOMobil_Delvac_MX_15W-40.aspx., Last accessed: 13/12/2012.
[4] Saurabh K., Mukherjee, P.S., 2005. Additives Depletion and Engine Oil Condition – A Case Study. Industrial Lubrication and Tribology 57, p. 69-72.
[5] Stachowiak, G.W., Batchelor, A.W., 2005. Engineering Tribology. Burlington, Elsevier Butterworth-Heinemann.
[6] Elvis, A., Shahrir, A., Kamal, A.A, Andanastuti, M., Khairuddin, 2009. Comparative Study of Characteristic of Lubricants Oils in Gasoline and Compressed Natural Gas Engines. European Journal of Scientific Research 30, p.282-293.
[7] Carigold, 2013. Mixture of HDEO and ATF. Website address: http://www.carigold.com, Last accessed: 15/07/2013.
[8] Bobistheoilguy, 2013. Mixture Dexron ATF and 15W-40 Engine Oil. Website address: http://www.bobistheoilguy.com, Last accessed: 15/07/2013.
[9] Malaysianbikerscommunity, 2013. HDEO Inside Motorcycle Engine. Website address: http://202.71.104.246, Last accessed: 15/07/2013.

[10] American Society for Testing and Materials (ASTM), 1998. ASTM D2270-93, 1998. Standard Practice for Calculating Viscosity Index From Kinematic Viscosity at 40 and 100°C.
[11] American Society for Testing and Materials (ASTM), 2010. ASTM D4172 – 94, 2010. Standard Test Method for Wear Preventive Characteristics of Lubricating Fluid (Four-Ball Method).
[12] Exxonmobil, 2013. Mobil Delvac MX™ 15W-40. Website address: http://www.exxonmobil.com/marinelubes-en/products_high-speed-engines_mobil-delvac-mx-15w-40.aspx#, Last accessed: 15/07/2013.
[13] Mobil, 2013. Mobil Delvac MX 15W-40. Website address: http://www.mobil.com/USA-English/Lubes/PDS/NAUSENCVLMOMobil_Delvac_MX_15W-40.aspx, Last accessed: 15/07/2013.
[14] Cosan , 2013. Mobil Delvac MXTM 15W-40. Website address: http://mobil.cosan.com.br/sites/default/files/mobil_delvac_mx_15w-40.pdf, Last accessed: 15/07/2013.
[15] Totaloil, 2013. ATF Dexron III Total. Website address: http://www.totaloil.com.au/Pages/content/NT0000BF6E.pdf, Last accessed: 15/07/2013.
[16] Citgo, 2013. Mistik Dexron III. Website address: http://www.docs.citgo.com/msds_pi/591262.pdf, Last accessed: 15/07/2013.